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Two new species of *Eimeria* and three new species of *Isospora* (Apicomplexa, Eimeriidae) from Brazilian mammals and birds

by R. Lainson and J. J. Shaw

Abstract. — Thirteen "four-eyed opossums", *Philander o. opossum*, from Pará State, north Brazil, were examined for coccidial oocysts in faecal samples. Five were infected with an eimerian, considered a new species, 2 with an isosporan which is possibly *I. boughtoni* Volk, and 2 with both these parasites. Oocysts of *Eimeria philanderi* n. sp., are spherical to subspherical and average 23.50 × 22.38 (21.25-27.50 × 18.75-25.00) μm : single polar body : no oocyst residuum. Oocyst wall 1.88 μm, with mamillated surface and composed of two striated layers, the inner brown-yellow and the outer colourless : no micropyle. Sporocysts average 11.35 × 8.13 (10.00-12.00 × 7.50-8.75) μm, oval to ellipsoidal, with prominent nipple-like Stieda body : residuum bulky, compact or scattered between two recurved sporozoites. Oocysts of the *Isospora* sp., close to *I. boughtoni* initially sub-spherical, 17.92 × 16.53 (16.25-20.00 × 13.75-18.75) μm : latterly deformed by collapse of the delicate, colourless wall : no micropyle, oocyst residuum or polar body. Sporocysts 13.35 × 9.88 (12.50-13.75 × 8.75-11.25) μm, ellipsoidal, with no Stieda body. Two of 5 "woolly opossums", *Caluromys p. philander*, were infected with an eimerian considered as a new species, *Eimeria caluromydis* n. sp. Oocysts spherical to subspherical, 31,83 × 31.15 (26.25-36.25 × 25.00-35.00) μm : no residuum or polar body. Oocyst wall brown-yellow, 3.21 (2.50-3.75) μm, striated, with coarsely mamillated surface : no micropyle. Sporocysts oval, 14.75 × 9.69 (12.50-16.25 × 8.75-10.00) μm : inconspicuous Stieda body, but a large sub-Stieda body : bulky sporocyst residuum. Two of 12 "squirrel monkeys", *Saimiri s. sciureus*, showed oocysts of an isosporan considered a new species, *Isospora saimiriae* n. sp. Oocysts 25.47 × 22.19 (23.75-27.50 × 18.75-23.75) μm, subspherical to ellipsoidal, no residuum or polar body : wall ~ 0.62 μm, single-layered colourless, no micropyle. Sporocysts 15.89 × 11.51 (15.00-16.25 × 11.25-12.50) μm, ellipsoidal, no Stieda body : bulky, compact residuum lying between 4 recurved sporozoites. Among 18 birds examined, a mixed infection with 2 isosporans, described as new species, was found in one "white-throated thrush", *Turdus albicollis*. Oocysts of *Isospora albicollis* n. sp., are oval, 24.53 × 20.03 (22.50-27.50 × 18.75-23.75) μm, with a single polar body ~ 3.00 × 2.00 μm, but no residuum : oocyst wall a single, colourless layer ~ 0.50-1.00 μm, with a conspicuous micropyle at the narrow end. Sporocysts 16.00 × 11.25 (12.00-15.00 × 8.00-10.00) μm, ellipsoidal, with prominent Stieda body. Sporozoites strongly recurved and enclosing bulky residuum. Oocysts of *Isospora tucuruiensis* n. sp., are spherical to subspherical, 17.28 × 17.06 (15.00-18.75 × 13.75-18.75) μm : single polar body ~ 2.50 × 2.00 μm. Oocyst wall single-layered, colourless and ~ 0.50-1.00 μm : no micropyle. Sporocysts 11.83 × 8.36 (10.00-12.50 × 7.50-10.00) μm, ellipsoidal, with prominent Stieda body. Sporozoites recurved at ends and enclosing a large residuum of granules and spherules.

Key-words. — Protozoa : Apicomplexa : Eimeriidae : parasites : Marsupialia : Primata : Aves : Brazil : *Eimeria philanderi* n. sp., *Isospora* sp., in *Philander o. opossum* : *Eimeria caluromydis* n. sp., in *Caluremys p. philander* : *Isospora saimiriae* n. sp., in *Saimiri s. sciureus* : *Isospora albicollis* n. sp., *Isospora tucuruiensis* n. sp., in *Turdus albicollis*.

Résumé. — *Deux nouvelles espèces d'*Eimeria *et trois nouvelles espèces d'*Isospora *(Apicomplexa, Eimeriidae), parasites de mammifères et d'oiseaux au Brésil.* — Treize « opossums quatre-yeux », *Philander o. opossum*, provenant de l'État du Pará, au nord du Brésil, ont été examinés à la recherche

d'oocystes coccidiaux dans des échantillons fécaux. Cinq étaient infectés par une *Eimeria*, décrite comme espèce nouvelle, deux par *Isospora* sp., aff. *boughtoni* Volk, et deux par ces deux parasites ensemble. Les oocystes sporulés d'*Eimeria philanderi* n. sp., sont sphériques ou subsphériques, mesurant 23,50 sur 22,38 (21,25-27,50 sur 18,75-25,00) µm, avec un seul granule polaire d'environ 4,00 sur 2,00 µm mais sans résidu oocystique. Paroi oocystique d'environ 1,88 µm d'épaisseur, à surface papuleuse; composée de deux couches striées, l'interne brun-jaune et l'externe incolore; pas de micropyle. Sporocystes mesurant 11,35 sur 8,13 (10,00-12,50 sur 7,50-8,75) µm, ovales ou ellipsoïdaux, avec un corps de Stieda en mamelon proéminent; résidu d'oocyste volumineux, condensé ou dispersé entre les deux sporozoïtes aux extrémités recourbées. Les oocystes de l'*Isospora* sp. aff. *boughtoni* sont tout d'abord subsphériques, mesurant 17,92 sur 16,53 (16,25-20,00 sur 13,75-18,75) µm, puis se déforment ensuite par modification de leur paroi qui est incolore et très fragile; micropyle, résidu de l'oocyste et granules polaires absents. Sporocystes de 13,35 sur 9,88 (12,50-13,75 sur 8,75-11,25) µm, ellipsoïdaux, sans corps de Stieda. Deux « opossums laineux », *Caluromys p. philander*, sur cinq étaient infectés par une *Eimeria* nouvelle, *Eimeria caluromydis* n. sp. Oocystes sphériques ou subsphériques, mesurant 31,83 sur 31,15 (26,25-36,25 sur 25,00-35,00) µm, sans résidu ni granule polaire. Paroi brun-jaune, de 3,21 (2,50-3,75) µm d'épaisseur, striée, à surface grossièrement papuleuse; pas de micropyle. Sporocystes ovales, mesurant 14,75 sur 9,69 (12,50-16,25 sur 8,75-10,00) µm, avec un petit corps de Stieda recouvrant un gros corpuscule (« sous-Stieda »); résidu d'oocyste volumineux. Deux parmi 12 « singes écureuils », *Saimiri s. sciureus*, ont fourni des oocystes d'une *Isospora* nouvelle, *Isospora saimiriae* n. sp. Oocystes mesurant 25,47 sur 22,19 (23,75-27,50 sur 18,75-23,75) µm, subsphériques ou ellipsoïdaux, sans résidu ni granule polaire; paroi d'environ 0,62 µm d'épaisseur, à une seule couche, incolore; pas de micropyle. Sporocystes mesurant 15,89 sur 11,51 (15,00-16,25 sur 11,25-12,50) µm, ellipsoïdaux, sans corps de Stieda, à résidu volumineux et compact disposé entre quatre sporozoïtes recourbés. Sur 18 oiseaux examinés, une « grive à cravatte », *Turdus albicollis*, présentait une infection mixte par deux nouvelles *Isospora*. Les oocystes d'*Isospora albicollis* n. sp. sont ovales, mesurant 24,53 sur 20,03 (22,50-27,50 sur 18,75-23,75) µm, n'ont qu'un seul granule polaire d'environ 3,00 sur 2,00 µm et pas de résidu; paroi à une seule couche incolore, d'environ 0,50 à 1,00 µm d'épaisseur, avec un micropyle net à l'extrémité la plus étroite. Sporocystes mesurant 16,00 sur 11,25 (12,00-15,00 sur 8,00-10,00) µm, ellipsoïdaux, avec un corps de Stieda en mamelon proéminent. Sporozoïtes fortement recourbés et délimitant un résidu volumineux. Les oocystes d'*Isospora tucuruiensis* n. sp. sont sphériques ou subsphériques, mesurant 17,28 sur 17,06 (15,00-18,75 sur 13,75-18,75) µm, avec un seul granule polaire d'environ 2,50 sur 2,00 µm. Paroi de l'oocyste à une couche, incolore, de 0,50 à 1,00 µm d'épaisseur, sans micropyle. Sporocystes de 11,83 sur 8,36 (10,00-12,50 sur 7,50-10,00) µm, ellipsoïdaux, avec un corps de Stieda en mamelon net. Sporozoïtes recourbés aux extrémités et entourant un important résidu de granules et de sphérules.

Mots-clés. — Protozoa. Apicomplexa. Eimeriidae. Parasites. Marsupialia. Primata. Aves. Brésil. *Eimeria philanderi* n. sp., *Isospora* sp. aff. *boughtoni* Volk chez *Philander o. opossum. Eimeria caluromydis* n. sp. chez *Caluromys p. philander. Isospora saimiriae* n. sp. chez *Saimiri s. sciureus. Isospora albicollis* n. sp., *Isospora tucuruiensis* n. sp., chez *Turdus albicollis*.

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Introduction

In August, 1984, studies on the fauna of tropical rain-forest in the Tucuruí area of Pará State, north Brazil, included the examination of faecal material from a number of mammals and birds trapped on the Island of Tocantins, in the Tocantins river (4°49′ S : 49°49′ W), approximately 75 km from Tucuruí. It is the object of this paper to describe some new species of coccidia encountered in this material.

Ironically, the type locality of the parasites in question is now beneath the waters of the

Tucuruí Reservoir, a man-made lake formed shortly after the present observations, when the new hydroelectric dam abruptly inundated some 2,430 sq. km. of Amazonian forest.

Material and methods

Faecal material was collected from 13 "four-eyed opossums", *Philander o. opossum* (Linn.) and 5 "woolly opossums", *Caluromys p. philander* (Linn.) (Marsupialia : Didelphidae); 14 "howler monkeys", *Alouatta b. belzebul* (Linn.), 12 "squirrel monkeys", *Saimiri s. sciureus* (Linn.), 3 "cuxiús", *Chiropotes s. satanus* (Hoffmansegg), and 1 "night monkey", *Aotus t. trivirgatus* (Humboldt) (Primata : Cebidae); 1 "marmoset", *Saguinus t. tamarin* (Link) (Primata : Callithricidae); 3 *Thamnophilus punctatus* (Shaw), 3 *Hylophylax naevia* (Gmelin), 2 *Formicarius colma* (Boddaert), and 2 *Myrmotherula axillaris* (Vieillot) (Passeriformes : Formicariidae); 1 *Pipra rubrocapilla* (Temminck) (Passeriformes : Pipridae); 2 *Arremon taciturnus* (Hermann), 1 *Cyanocompsa cyanoides* (Lafresnaye) (Passeriformes : Fringillidae); 1 *Xiphorhynchus guttulus* (Lichtenstein) (Passeriformes : Dendrocolaptidae); 1 *Automolous infuscatus* (Sclater) (Passeriformes : Furnariidae); 1 *Turdus albicollis* (Vieillot) (Passeriformes : Turdidae) and 1 *Micrastur ruficollis* (Vieillot) (Falconiformes : Falconidae).

Freshly passed faeces, or rectal contents removed at autopsy, were put into small vials containing 2.0 % (w/v) aqueous $K_2Cr_2O_7$ solution. In the field these were kept, unstoppered, in a polystyrene box to protect against excessive heat : on return to the laboratory the samples were lightly triturated in the same fluid, placed in sterile Petri-dishes and maintained at approximately 24° C pending the first examination, from 9-14 days after the specimens were collected.

Oocysts were examined in unconcentrated, unsieved suspensions. Drawings were made using a Zeiss WL Research microscope with × 8 eyepieces and a × 100 neofluar objective, and a calibrated ocular micrometer. All measurements are given in micrometers (μm) as means, and with standard deviations : size ranges are given in parentheses. Photomicrographs were prepared with a Zeiss "Microflash II" and AGFA PAN 25 film.

Results

Marsupials : Nine of the 13 specimens of *P. o. opossum* examined were passing abundant coccidial oocysts. Of these, 5 were infected with an *Eimeria*, 2 with an *Isospora* and 2 with both of these parasites.

Two of the 5 *C. p. philander* were infected with another *Eimeria* species.

Primates : Two of the 12 *S. s. sciureus* were passing very scanty oocysts of an *Isospora* species. No coccidial infections were detected in any of the other monkey species.

Birds : Of the 18 birds examined, a single specimen of *Turdus albicollis* showed abundant oocysts of two different *Isospora* species.

Four of the five coccidia encountered are described below as new species.

Eimeria philanderi n. sp.

(Pl. I, 1-3, and fig. 1)

Oocysts : Spherical to subspherical, 23.50 ± 1.47 × 22.38 ± 1.14 (21.25-27.50 × 18.75-25.00) for 50 measured, with a polar body ~ 4.00 × 2.00 : no oocyst residuum. Oocyst wall ~ 1.88, with a mamillated surface and composed of two striated layers, the outer of which is colourless and the inner brown-yellow : no micropyle.

Sporocysts : Oval to ellipsoidal, 11.35 ± 0,61 × 8.13 + 0,63 (10.00-12.50 × 7.50-8.75) for 50 measured. Prominent nipple-like Stieda body, but no sub-Stieda body : residuum of granules and spherules, usually concentrated between the two recurved sporozoites : no refractile bodies seen.

Sporulation time : Five days (at ~ 24° C). As ascertained in material subsequently obtained in Belém.

TYPE HOST : *Philander opossum opossum* (Linn.) (Marsupialia : Didelphidae). The "four-eyed opossum". Lodged with the Smithsonian Institution, Washington D.C., USA.

SITE OF INFECTION IN HOST : Not determined : probably in the intestinal tract.

TYPE LOCALITY : Island of Tocantins, Pará State, north Brazil (4°49' S : 49°49' W). Now submerged beneath the Tucuruí Reservoir.

DIFFERENTIAL DIAGNOSIS

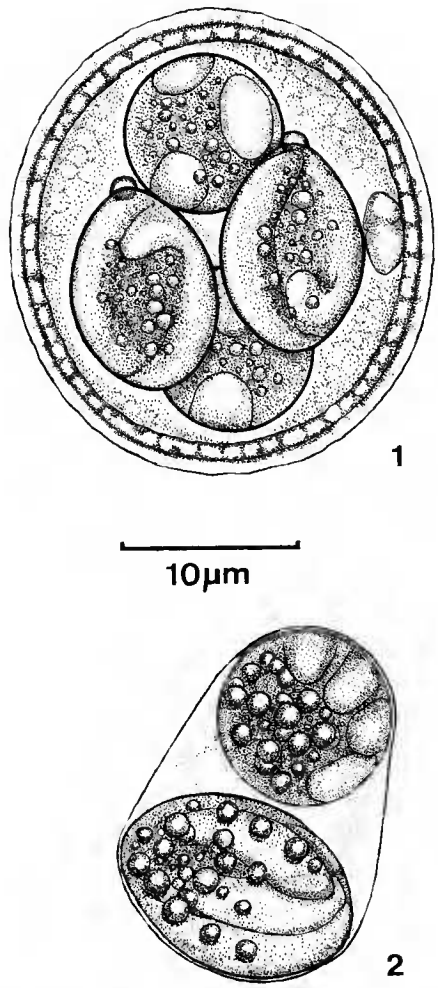
No *Eimeria* species have previously been described from *P. o. opossum*, although four have been named from other genera of opossums in Brazil (CARINI, 1936, 1937 and 1938) and North America (JOSEPH, 1974).

Oocysts of *E. didelphydis* Carini, 1936, from the opossum *Didelphis auritus* resemble those of *E. philanderi* only in that they are spherical : they are much smaller (mean 16.00 in diameter) and also differ in having a smooth, colourless oocyst wall, no polar body, and a sporulation time of 8 days compared with that of 5 days recorded for *E. philanderi*.

The oocysts of *E. gambai* Carini, 1938, from the same species of opossum, do have a thick brown-yellow wall, similar to that of *E. philanderi*, but they are ellipsoidal (23.00-28.00 × 18.00-22.00), and CARINI figures them without a polar body.

E. haberfeldi Carini, 1937, from *Caluromys p. philander*, also has a brown-yellow, striated oocyst wall. The oocysts are larger than those of *E. philanderi*, however (mean 30.00 × 20.00), elipsoidal and without a polar body.

Finally, *E. indianensis* Joseph, 1974, from the North American opossum *Didelphis virginiana*, is superficially similar to *E. philanderi*, the oocysts being spherical to subspherical and having a thick, double-layered wall which is "... yellowish, striated, rough and pitted". The oocysts are very much smaller than those of *E. philanderi*, however, averaging only 16.30 (spherical) or 17.60 × 16.40 (subspherical), compared with an average of 23.50 × 22.38. The sporocysts are also smaller, measuring only 9.10 × 6.20, compared with 11.35 × 8.13. Finally, the sporulation times for *E. indianensis* and *E. philanderi* are 10 and 5 days, respectively, at approximately the same temperature (22-24° C).



FIGS. 1-2. — Line drawings of coccidia encountered in the faeces of the opossum *Philander o. opossum* : 1, mature oocyst of *Eimeria philanderi* n. sp.; 2, mature oocyst of an isosporan, possibly *Isospora boughtoni* Volk.

Isospora sp., possibly **I. boughtoni** Volk, 1948
(Pl. I, 7-9, and fig. 2)

Oocysts : Initially spherical to subspherical, 17.92 ± 1.40 × 16.53 ± 1.50 (16.25-20.00 × 13.75-18.75) for 50 measured, but becoming distorted by collapse of the delicate, colourless wall. Latterly the parasites are mostly seen as freed sporocysts in the faeces. No micropyle, oocyst residuum or polar body.

Sporocysts : Ellipsoidal, with no Stieda body. Prominent sporocyst residuum of granules

and spherules : four sporozoites of ~ 8.75 × 2.50. Sporocysts measure 13.35 ± 0.59 × 9.88 ± 0.46 (12.50-13.75 × 8.75-11.25), for 50 measured.

Sporulation time : Undetermined, but within 14 days.

HOST : *Philander o. opossum* (Linn.).

SITE OF INFECTION IN HOST : Undetermined : probably the intestinal tract.

LOCALITY : Island of Tocantins, Pará State, north Brazil.

VOLK (1938) described *I. boughtoni* from *Didelphis virginiana*, in North America, and ERNST *et al.* (1969), recorded the same parasite in *D. marsupialis* (Syn. *D. virginiana)* in Alabama, USA. They also recorded the presence of another *Isospora* in this opossum, which differed in having a pale yellow oocyst wall and sporocysts with a prominent Stieda body, but refrained from naming it because the opossum had recently eaten a bird and it was felt that there was doubt as to which animal the parasite belonged.

JOSEPH (1974) rediscovered what he considered to probably be the *Isospora* encountered by ERNST *et al.*, in a specimen of *D. virginiana* from Indiana, USA : he, too, was reluctant to name the organism in the absence of conclusive evidence that it was a true parasite of the opossum.

The isosporan oocysts we describe above, from *P. o. opossum*, are certainly not those of the unnamed *Isospora* sp., discussed above, from which they differ in their smaller size and absence of a Steida body. They are, however, very similar to *I. boughtoni* and until such time as a more detailed comparison is possible we refrain from giving a new name to the Brazilian parasite.

Eimeria caluromydis n. sp.

(Pl. I, 4-6, and fig. 3)

Oocysts : Spherical to subspherical, 31.83 ± 1.72 × 31.15 ± 2.00 (26.25-36.25 × 25.00-35.00) for 50 measured : no oocyst residuum or polar body. Wall brown-yellow, 3.21 ± 0.46 (2.50-3.75) for 50 measured : striated, seemingly of a single layer, with no micropyle, and having a prominently mamillated surface.

Sporocysts : Oval (egg-shaped), 14.75 ± 1.04 × 9.69 ± 0.56 (12.50-16.25 × 8.75-10.00) for 20 measured, with an inconspicuous Stieda body but a large sub-Stieda body : bulky sporocyst residuum of granules and spherules.

Sporulation time : Not determined, but within 14 days.

TYPE HOST : *Caluromys p. philander* (Linn.). The "woolly opossum". Lodged with the Smithsonian Institution, Washington D.C., USA.

SITE OF INFECTION IN HOST : Not determined; probably the intestinal tract.

TYPE LOCALITY : Island of Tocantins, Pará State, north Brazil.

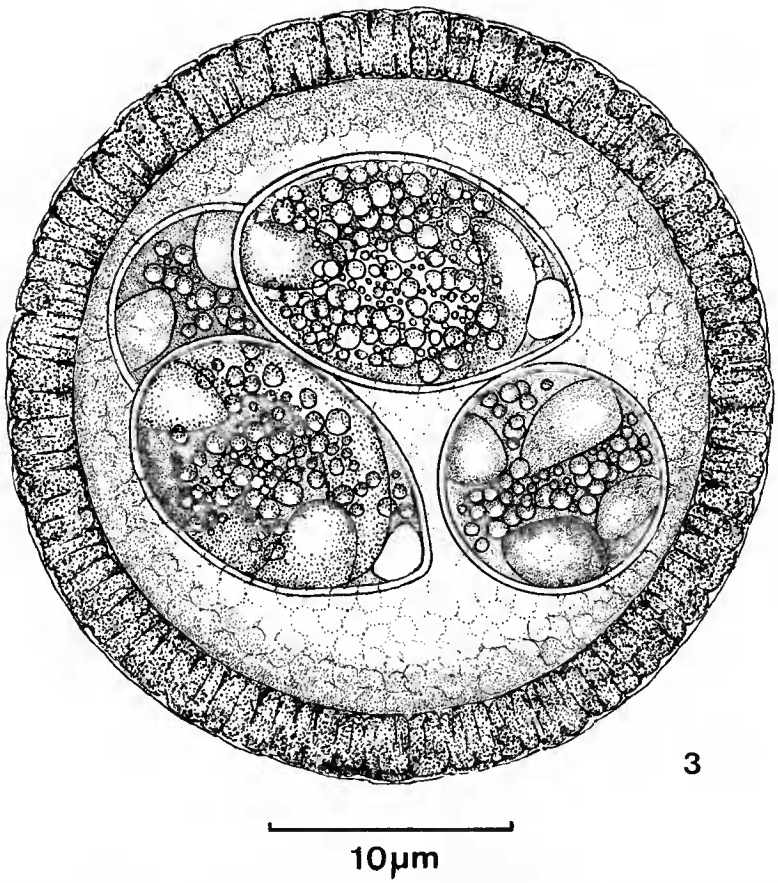


FIG. 3. — Line drawing of a mature oocyst of *Eimeria caluromydis* n. sp., in the faeces of the opossum *Caluromys p. philander*.

DIFFERENTIAL DIAGNOSIS

The remarkably thick, dense and mammillated wall of *E. caluromydis* effectively distinguishes the parasite from the four other *Eimeria* species described from American marsupials and, in addition, the oocysts of *E. gambai* and *E. haberfeldi* are ovoid.

While *E. didelphydis* and *E. indianensis* do have spherical to subspherical oocysts, they are only one half the size of those of *E. caluromydis*, and the oocyst wall of *E. didelphydis* is colourless and smooth. Finally, while the sporocysts of all the *Eimeria* species of marsupials discussed above do possess conspicuous Stieda bodies, none of them have the voluminous sub-Stieda body seen in *E. caluromydis*.

Thick-walled, brown-yellow oocysts are also a feature of *Eimeria* species from edentates. CARINI (1933) described *E. tatusi* of armadillos as having dark yellow, spherical oocysts of 30.00-33.00 in diameter, with a striated wall about 3.00 thick. Superficially these resemble

those of *E. caluromydis*, but the sporocysts of the former are smaller (15.00-17.00 × 10.00-11.00) and, although they have a conspicuous Stieda body, there is no sub-Stieda body. LAINSON & SHAW (1982) described the oocysts of *E. choloepi*, from the sloth *Choloepus didactylus*, and *E. cyclopei* from the silky anteater *Cyclopes didactylus*, as both having an ellipsoidal to subspherical shape and a thick yellowish wall. The oocysts and sporocysts of the former are smaller than those of *E. caluromydis* (19.0-25.00 × 17.00-25.00 and 10.00-12.50 × 6.30-7.50, respectively) and there is no sub-Stieda body. The oocyst wall is distinctly two-layered. The oocysts of *E. cyclopei* approach more closely those of *E. caluromydis* in size (range 22.9-31.7 × 17.8-26.7), but the sporocysts are an elongate pear-shape (17.5-20.3 × 8.5-10.0) and are without a sub-Stieda body. The oocyst wall is of at least two layers.

Isospora saimiriae n. sp.

(Pl. II, 10-11, and fig. 4)

Oocysts :Subspherical to ellipsoidal, 25.47 ± 0.92 × 22.19 ± 1.28 (23.75-27.50 × 18.75-23.75) for 12 measured, no oocyst residuum or polar body. Wall a single layer ~ 0.62, smooth, colourless and with no micropyle.

Sporocysts : Ellipsoidal, 15.89 ± 0.47 × 11.51 ± 0.42 (15.00-16.25 × 11.25-12.50) for 20 measured : no Stieda or sub-Stieda bodies. Very bulky, compact residuum of granules and spherules lying between the four elongate sporozoites, which are curved along their length.

Sporulation time : Within 24 hours (at ~ 24° C), as ascertained from one of the infected monkeys returned to Belém.

TYPE HOST : *Saimiri s. sciureus* (Linn.). The "squirrel monkey". National Primate Centre, Ananindeua, Pará, Brazil.

SITE OF INFECTION IN HOST : Not determined : probably in the intestinal tract.

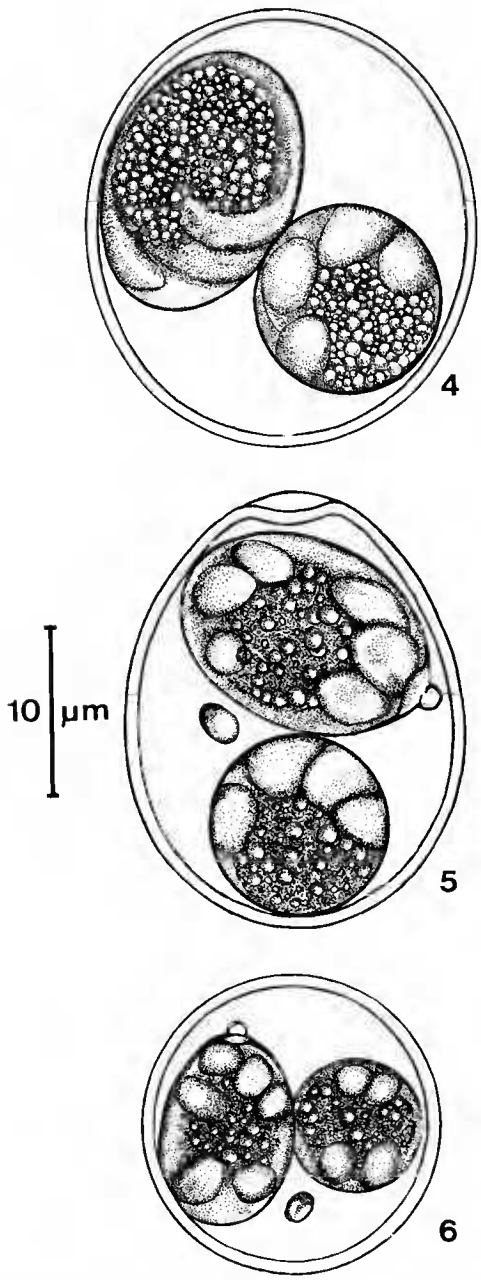
TYPE LOCALITY : Island of Tocantins, Pará State, north Brazil.

DIFFERENTIAL DIAGNOSIS

ARCAY-DE-PERAZA (1967) recorded *I. scorzai* from a Brazilian monkey, *Cacajao rubicundus*, captive in the London Zoo, and succeeded in experimentally infecting *Cebus nigrivittatus*. This parasite is substantially smaller than *I. saimiriae* (oocysts 23.00 × 19.00 : sporocysts 14.30 × 9.10), however, and was said to have a bi-layered wall. In addition, the sporozoites are described as "kidney-shaped", whereas those of *I. saimiriae* are elongate and relatively slim. Finally, the sporulation time of *I. scorzai* is given as 4 days, while that of *I. saimiriae* is within 24 hours.

RODHAIN (1933) described *I. arctopitheci* from the marmoset, *Callithrix penicillata*. The oocysts are considerably larger than those of *I. saimiriae* (27.00-33.00 × 21.00-24.00), and the delicate oocyst wall usually collapses and molds itself closely around the sporocysts.

MARINKELE (1969) recorded *I. cebi* from *Cebus albifrons*, in Colombia : this parasite is distinguished from *I. saimiriae* by its smaller oocysts (25.9 × 19.8) and the sporocysts which bear a distinct Stieda body.



FIGS. 4-6. — Line drawings of coccidia encountered in the faeces of Brazilian mammals and birds : *Isospora saimiriae* n. sp., from the monkey *Saimiri s. sciureus* : mature oocyst ; 5-6, mature oocysts of *Isospora albicollis* n. sp., and *Isospora tucuruiensis* n. sp., both from the passerine *Turdus albicollis*.

Isospora albicollis n. sp.
(Pl. II, 12, and fig. 5)

Oocysts : Oval (egg-shaped), 24.53 ± 1.07 × 20.03 ± 1.09 (22.50-27.50 × 18.75-23.75), no oocyst residuum but with a single polar body ~ 3.00 × 2.00. Wall smooth, colourless and of a single layer about 0.50-1.00 thick : conspicuous micropyle at the narrow end, where the wall bulges inwards.

Sporocysts : Ellipsoidal, 16.00 ± 0,71 × 11,25 ± 0.71 (12.00-15.00 × 8.00-10.00), with a prominent, nipple-like Stieda body associated with a thickened anterior portion of the sporocyst wall. There is a bulky residuum of granules and spherules enclosed by the four recurved sporozoites, in which refractile bodies were not seen.

Sporulation time : Not determined, but within 14 days.

TYPE HOST : The " White-throated Thrush ", *Turdus albicollis* (Vieillot). Specimen MG-5391 lodged in the Museu Paraense Emílio Goeldi, Belém, Pará, Brazil.

SITE OF INFECTION IN HOST : Not determined : probably in the intestinal tract.

TYPE LOCALITY : Island of Tocantins, Pará State, north Brazil.

DIFFERENTIAL DIAGNOSIS

I. lacazei (Labbé) is generally regarded as the most common and widely distributed isosporan of passerine birds : it is readily distinguished from *I. albicollis* by its lack of a micropyle, absence of a polar body, and piriform sporocysts (PELLERDY, 1974) : the only isosporan previously recorded in the genus *Turdus* is *I. turdi* Schwalbach, 1959, in the European blackbird *Turdus merula*, and it, too, lacks a micropyle.

Among the other species of *Isospora* from birds, *I. garrulusae* Ray, Shivrani, Oommen & Bhaskaran, 1952, resembles *I. albicollis* in size (25.00-27.00 × 20.00-25.00) and shape of the oocyst, which also possesses a micropyle and a polar body (sometimes two). The sporocysts differ, however, in their piriform shape. *I. garrulusae* was described in the " Himalayan jay ", *Garrulus glandarius bispecularis* in India.

GRULET *et al.* (1982) indicated something of the complexity of avian isosporan taxonomy when they described no less than 12 different species of *Isospora* in the common house-sparrow, *Passer domesticus*, in France (*I. boxae, I. frenkeli, I. gonnetae, I. iansmithi, I. fatiguei, I. kouyatei, I. michaelbakeri, I. miltgeni, I. mikei, I. spratti* and *I. yesi*). Some or all of these parasites have probably been confused with *I. lacazei* in the past : their oocysts are all differentiated from those of *I. albicollis* by their rounded shape, smaller size and lack of a micropyle.

BLANC & GRULET (1985) described *I. vagoi* in the passerine *Poephila guttula*. It, too, differs from *I. albicollis* on the same characters and its possession of a distinct oocyst residuum.

Of four new *Isospora* species described from the finch *Camarhynchus parvulus*, on the Galapagos Islands (MCQUISTION & WILSON, 1988), only *I. temeraria* has ellipsoid to egg-

shaped oocysts : they differ from *I. albicollis* in their smaller size, lack of a micropyle, and their yellow-brown wall.

Finally, oocysts of *I. paddae* and *I. indonesianensis* Amoudi, 1988, from the Indonesian passerines *Padda oryzivora* and *Lonchura malacca*, are much larger than those of *I. albicollis*, subspherical, without a micropyle or polar body, and with a thick, coloured oocyst wall.

Isospora tucuruiensis n. sp.

(Pl. II, 13-16, abd fig. 6)

Oocysts : Spherical to subspherical, 17.28 ± 0.94 × 17.06 ± 0.93 (15.00-18.75 × 13.75-18.75), with no oocyst residuum, but a single polar body of ~ 2.50 × 2.00. Wall colourless, of a single layer and with no micropyle : about 0.50 to 1.00 thick.

Sporocysts : Ellipsoidal, 11.83 ± 0.74 × 8.36 ± 1.35(10.00-12.50 × 7.50-10.00), with a conspicuous nipple-like Stieda body associated with a slight thickening of the anterior part of the sporocyst wall. Sporozoites recurved at their ends and enclosing a substantial residuum of small granules and spherules : sporozoite refractile bodies were not seen.

Sporulation time : Not determined, but within 14 days.

TYPE HOST : *Turdus albicollis*. The same specimen also infected with *I. albicollis* (see above).

SITE OF INFECTION IN HOST : Not determined : probably in the intestinal tract.

TYPE LOCALITY : Island of Tocantins, Pará State, north Brazil.

DIFFERENTIAL DIAGNOSIS

We have found no evidence that *I. tucuruiensis* produces other than spherical or subspherical oocysts, and have, therefore, discluded comparison of this parasite with a number of avian isosporans said to have both spherical and oval (egg-shaped) oocysts.

The average size of *I. lacazei* (Labbé, 1893) sensu Anwar, 1966, is 23.4 diameter (range 16.6-30.0), which is considerably larger than the oocysts of *I. tucuruiensis* and, in addition, the sporocysts of *I. lacazei* are piriform in shape. This latter feature also separates *I. tucuruiensis* from a number of other avian isosporans which have similar oocyst measurements : namely, *I. monedulae* Yakimoff & Matschoulsky, 1936, *I. rodhaini* Yakimoff & Matschoulsky, 1938, *I. schwetzi* Yakimoff & Matschoulsky, 1939, and *I. garrulae* Ray, Shirnani, Oommen & Bhaskaran, 1952.

I. corviae Ray, Shirnani, Oommen & Bhaskaran, 1952, and an unnamed *Isospora* species described by MISRA (1947), both have oocysts and sporocysts morphologically similar to those of *I. tucuruiensis*, but the former has pale pink oocysts and the latter a thick, double-layered oocyst wall which has a yellow inner layer.

I. tucuruiensis does have some features in common with the above-mentioned *Isospora* species described in *Passer domesticus* by GRULET *et al.*; namely, spherical oocysts with a colourless wall lacking a micropyle. It differs from them, however, in the much smaller size of the oocyst. *I. vagoi* is readily differentiated by its larger oocysts and the possession of an

oocyst residuum. The rounded oocysts of *I. exigua, I. rotunda* and *I. fragmenta* McQuistion & Wilson, 1988, are distinguished by their larger size, brown-yellow wall (the first two) and the large number of "splinter-like" polar bodies in the oocyst of the last parasite.

Finally, the only isosporan previously described from the genus *Turdus, I. turdi* from the European blackbird, is differentiated from *I. tucuruiensis* by its oval oocysts, which average 19.00 × 16.00.

Concluding remarks

Field conditions did not permit observations on the sporulation time of most of the parasites discussed above : exceptions being that of *I. saimiriae* in a monkey taken to Belém, and of *E. philanderi* which was studied in material from an animal brought to our laboratory. Neither was it possible to determine the site and nature of the infection in the respective vertebrate hosts. These features might well provide useful additional taxonomic criteria, and it is hoped that these gaps in our knowledge may be filled following the study of further infected animals.

Finally, in our hands the preservation of oocysts in such fixatives as formol-saline has proved unsatisfactory. "Phototypes" (photomicrographs of the type specimens) are deposited with the Department of Parasitology, The Instituto Evandro Chagas, Belém, Pará, Brazil, and the Muséum national d'Histoire naturelle (Laboratoire des Vers), Paris (P 6555).

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Plate I

1-3 — Mature oocysts of *Eimeria philanderi* n. sp., in the faeces of the opossum *Philander o. opossum*. S = Stieda body; P = polar body; fig. 3 shows the finely mamillated surface of the oocyst wall.

4-6 — Mature oocysts of *Eimeria caluromydis* n. sp., in the faeces of the opossum *Caluromys p. philander*. The thick wall makes it difficult to see the contents (fig. 4). Figure 5 shows the coarsely mamillated wall in surface view, and figure 6 after rupture of an oocyst to liberate the sporocysts. SS = sub-Stieda body.

7-9 — *Isospora* sp., possibly *I. boughtoni* Volk, 1938, in the faeces of the opossum *P. o. opossum*. The oocyst wall is scarcely visible (fig. 7 & 8), usually breaking down to leave the sporocysts free in the faeces (fig. 9).

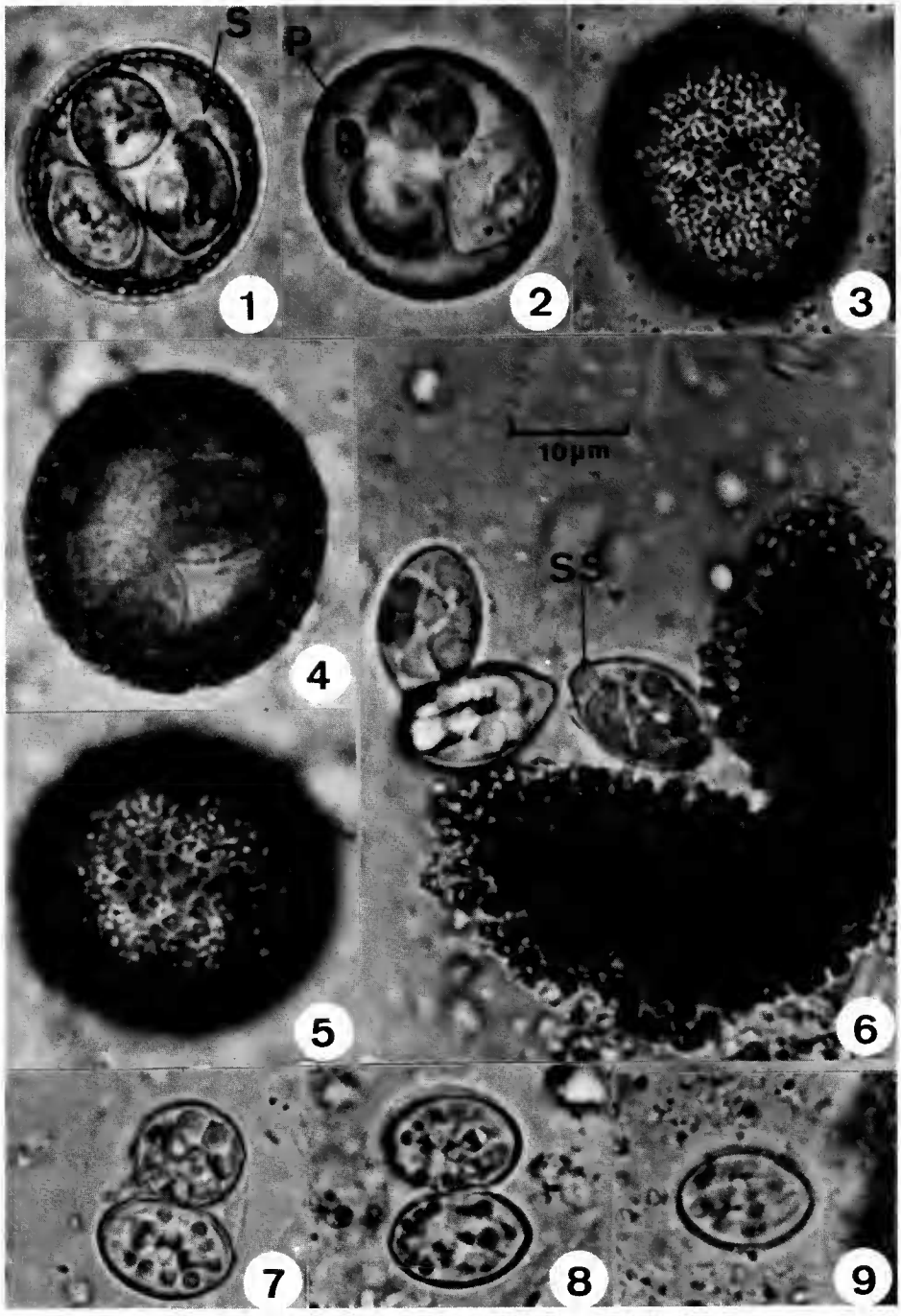

PLATE I

PLATE II

10-11 — *Isospora saimiriae* n. sp., in the faeces of the monkey *Saimiri s. sciureus*. Note elongate, curved sporozoites (SP) enclosing the bulky, compact sporocyst residuum.

12 — Mature oocysts of *Isospora albicollis* n. sp., in faeces of the passerine bird *Turdus albicollis*. M = oocyst micropyle; P = polar body; S = Stieda body.

13-16 — *Isospora tucuruiensis* n. sp., in the faeces of the same bird. Figure 3 shows the basic, spherical-subspherical shape of the oocyst; figure 14 a ruptured oocyst, confirming the presence of a single oocyst-wall layer. S = Stieda body; P = polar body.

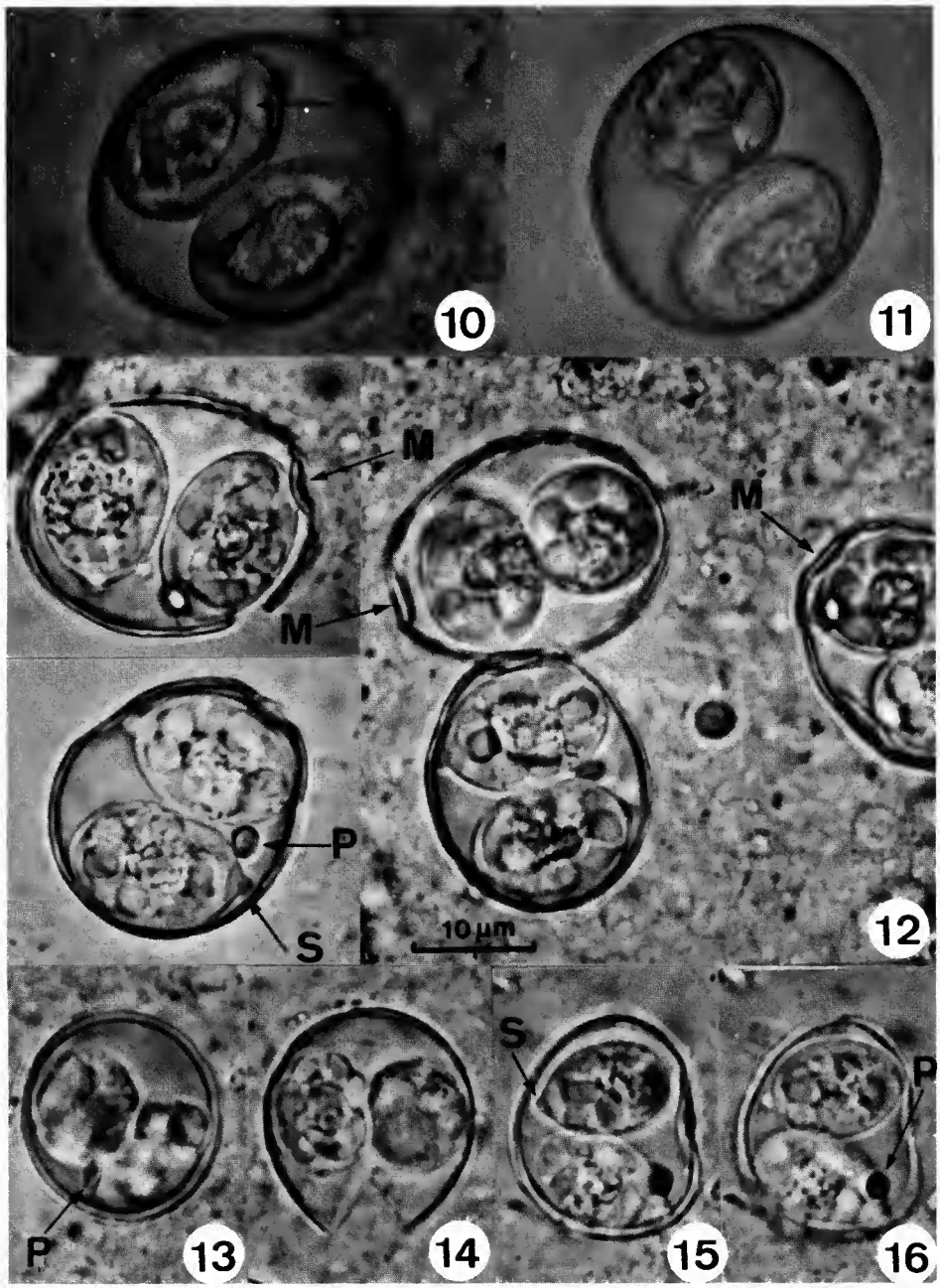

PLATE II